An improved model for the OT digitisation II

Gruppentreffen 08/08/07

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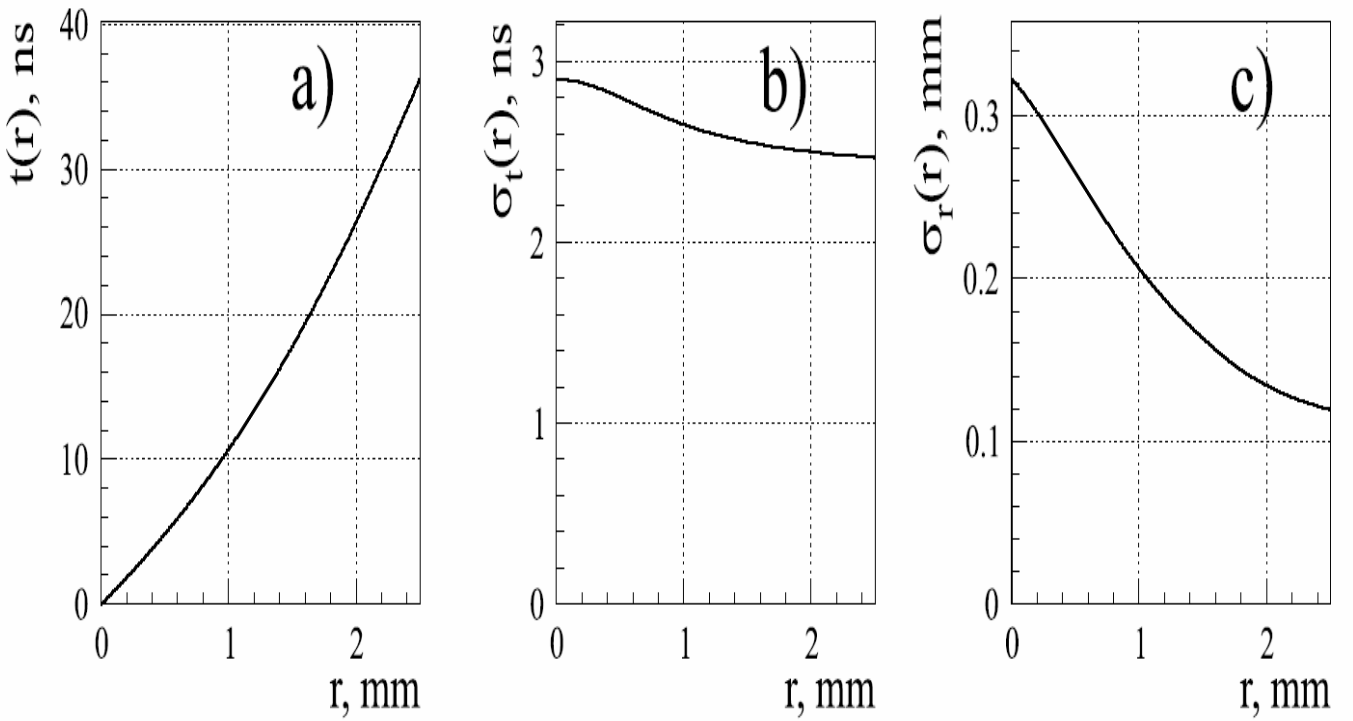
Motivation

The current implementation of the OT-digitisation is based on a parametrization of the testbeam results for time resolution and efficiency.

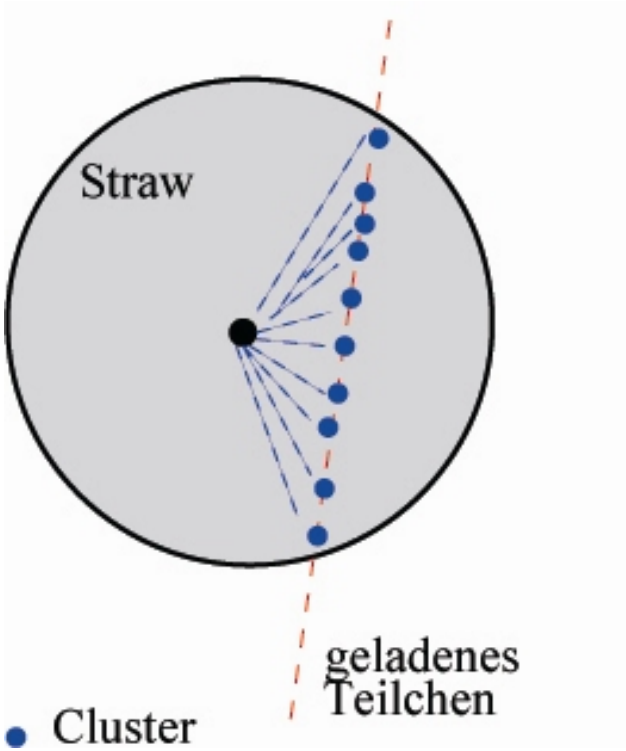
The idea of the new approach is to simulate the basic physical processes and get detector performance as as output.

Input from test beam



$$\sigma_r(r) = \frac{\sigma_t(r)}{dt(r)/dr}$$

MIPs in straw tubes



- MIP ionizes along its trajectory.

  Ionization follows Poisson-distrib.

- Electron from ionization process may have enough energy to produce secondary electrons.

  Number of electrons n_s : $\overline{n_s} \approx 3$

  $$\mathrm{Prob}(n_s) \sim 1/n_s^2$$

- Electrons drift to anode (diffusion!)

- Gas amplification takes places:

  # electrons produced for per electron follows polya distribution.

The improved model

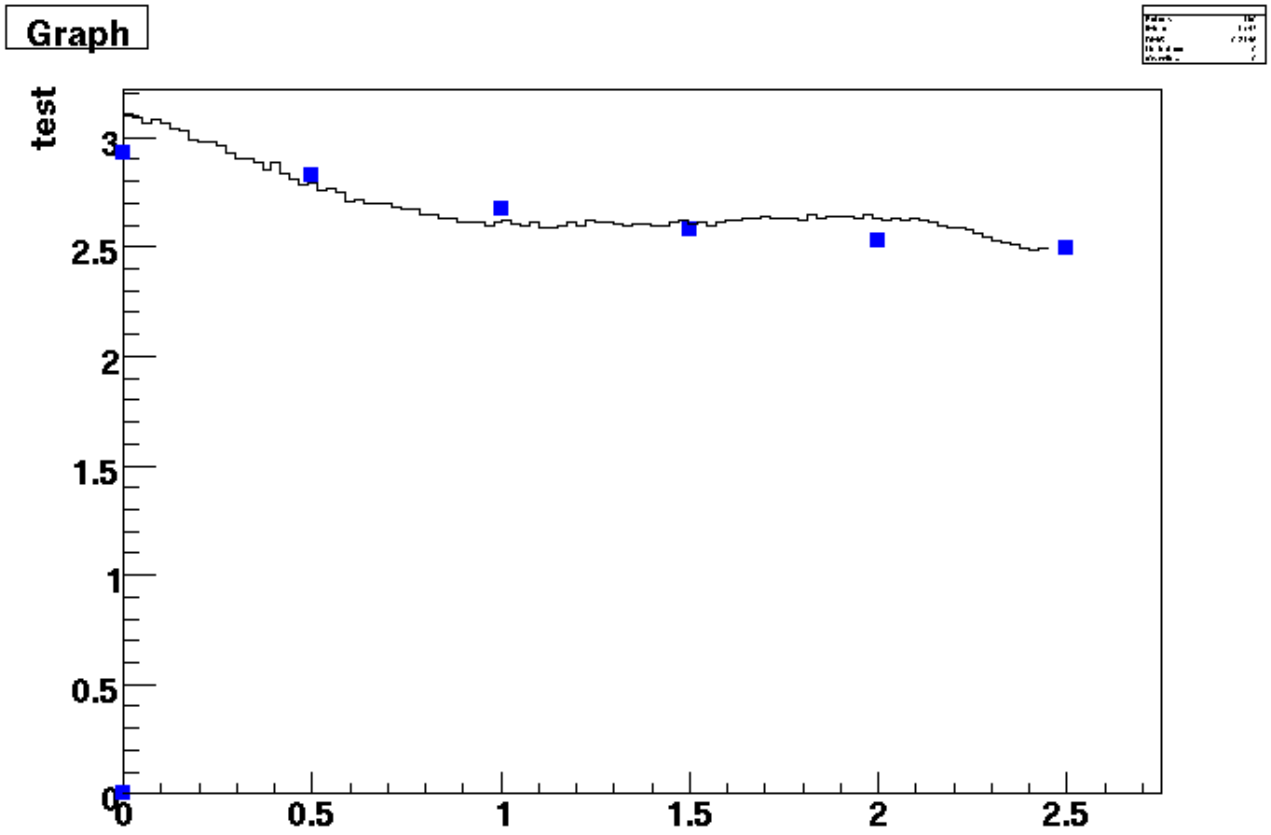
Take into account:

- Primary ionization following Poisson statistics.
  (Primary ionization density taken from literature.)
- Statistics for secondary ionization.
- Statistics of gas amplification process
  (following polya-distribution).
- Signal has to exceed a threshold to trigger.
- Non-linear rt-relation.
- Contribution of electronics to measurement error (σ_t = const.)
- Diffustion ($\sigma_t \sim \sqrt{t}$)
  (diffusion constant estimated by Garfield)

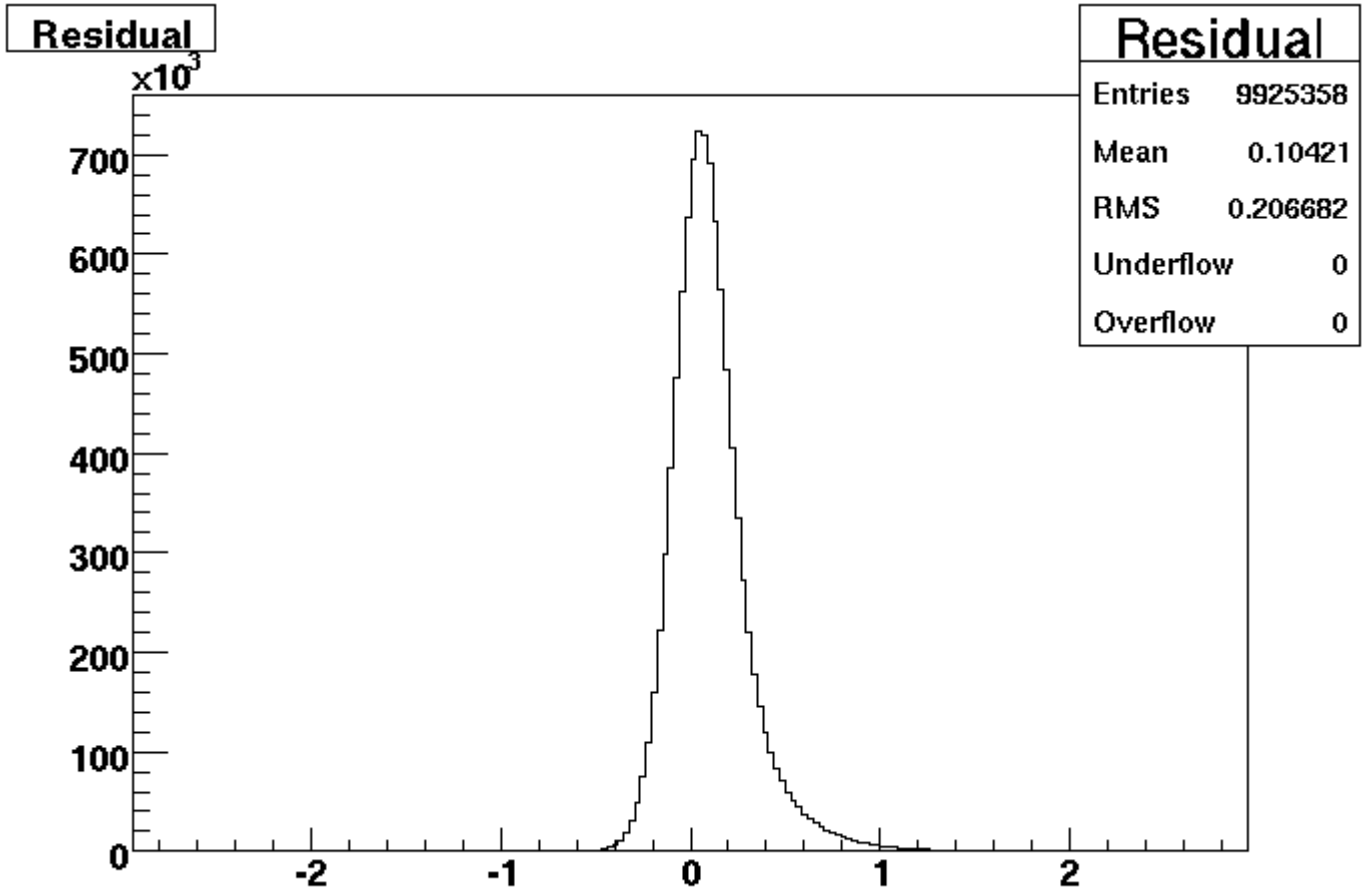
In total 2 free parameters.

Tuning parameters

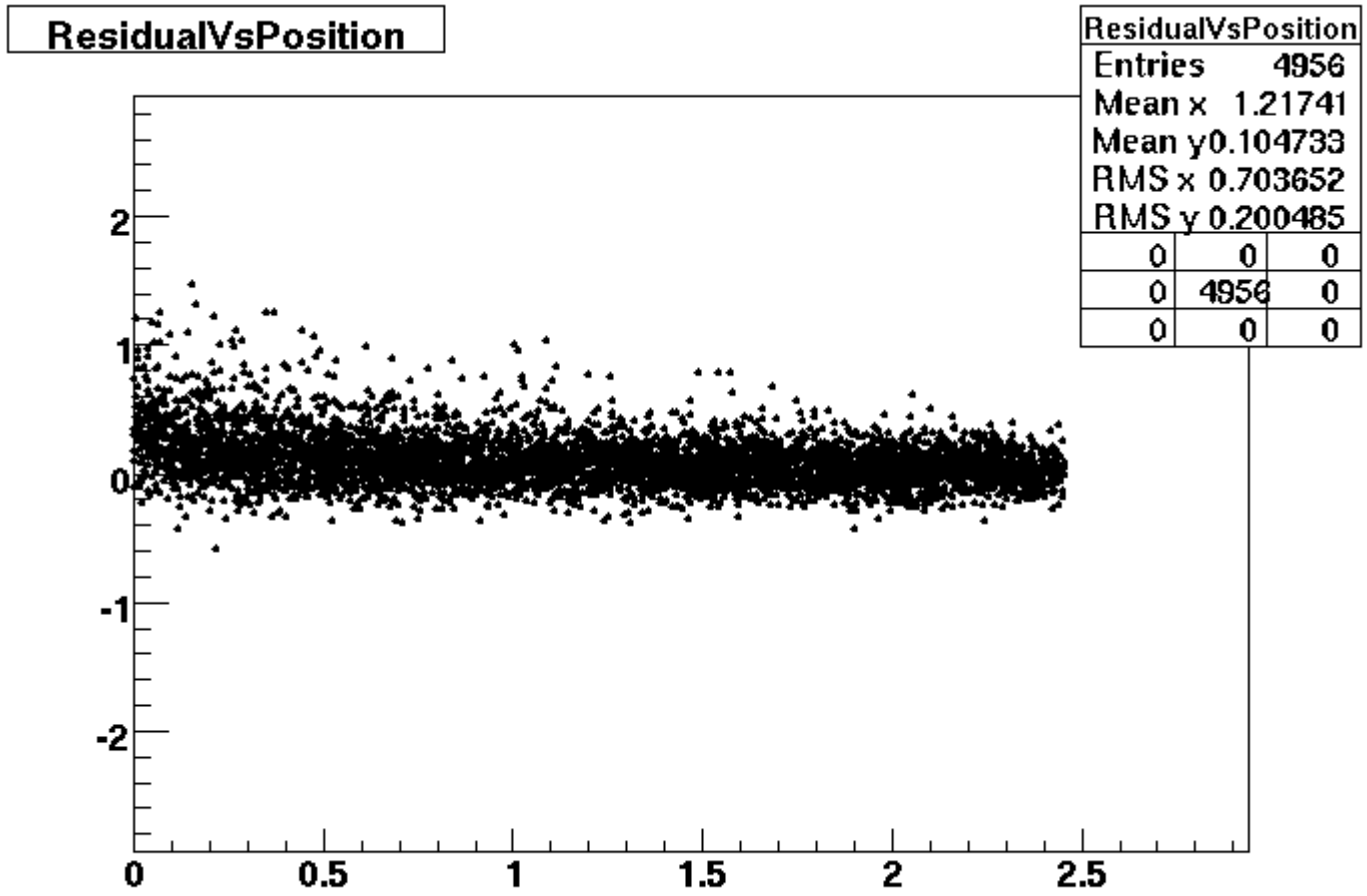
- Two parameters adapted to fit time resolution:
  - Threshold
  - Time jitter σ_t



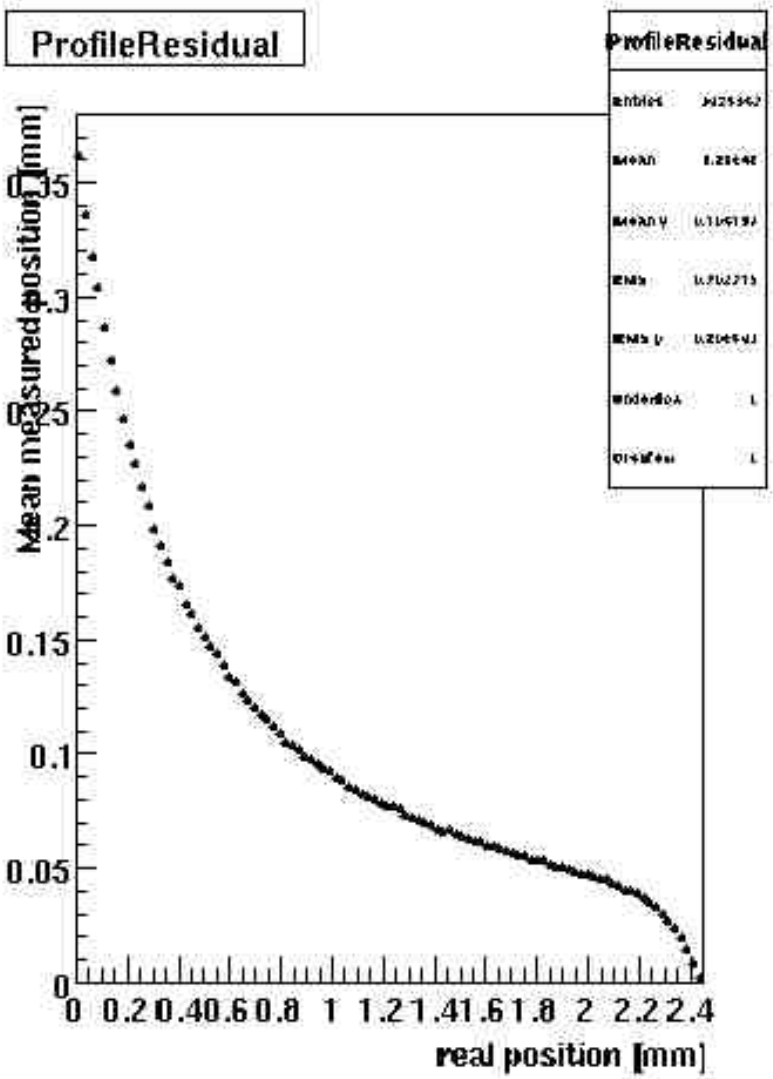
Results: Residual

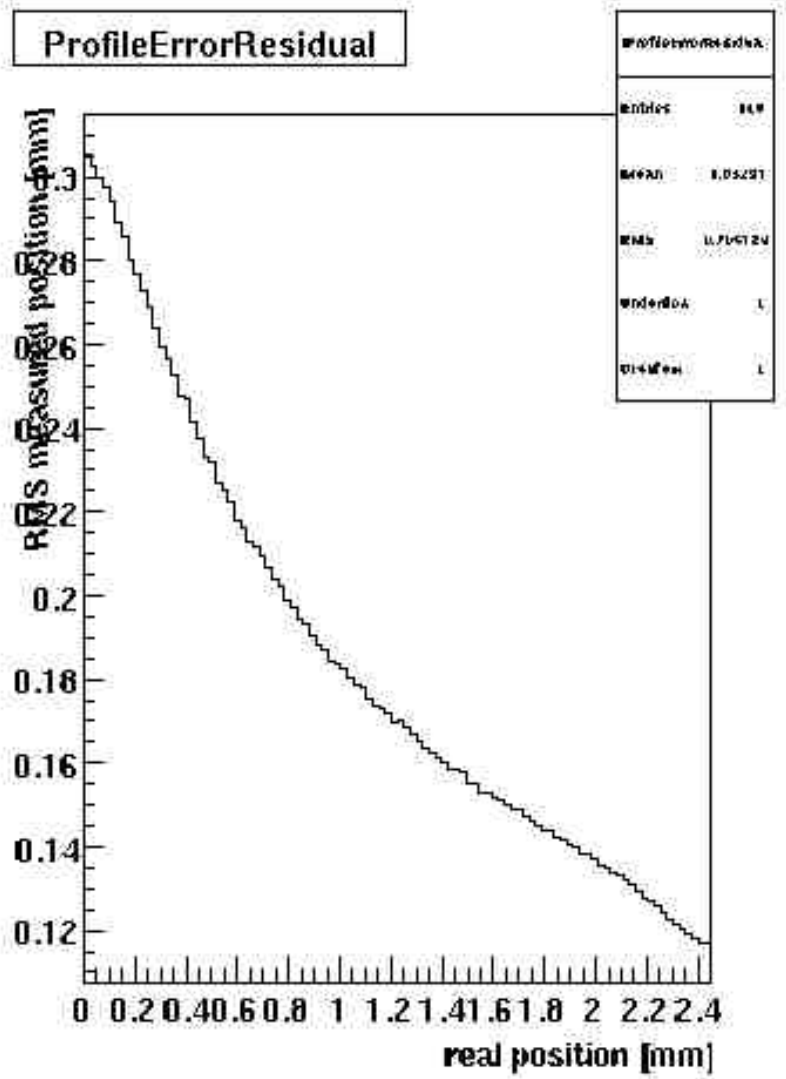


Results: Residual vs. Position

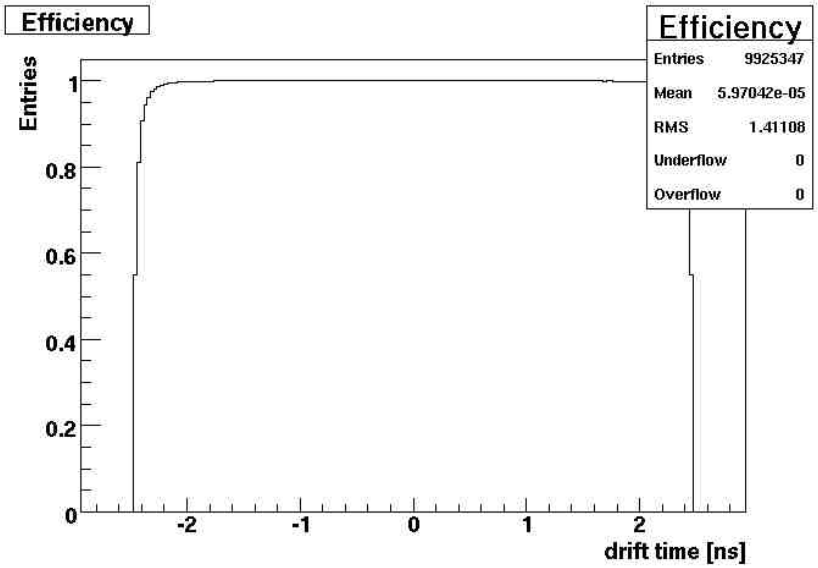


Mean and RMS for Residual vs. Position

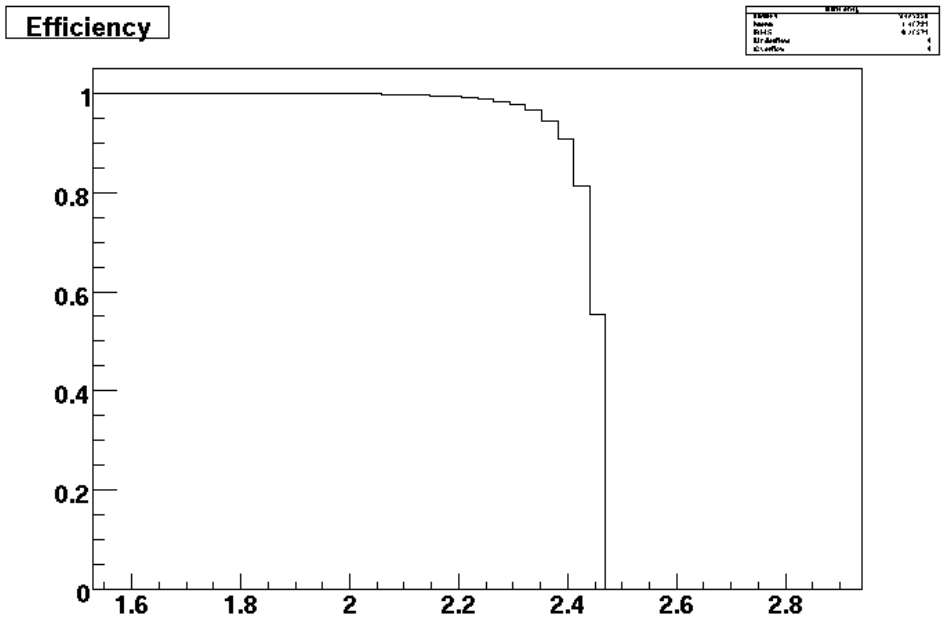




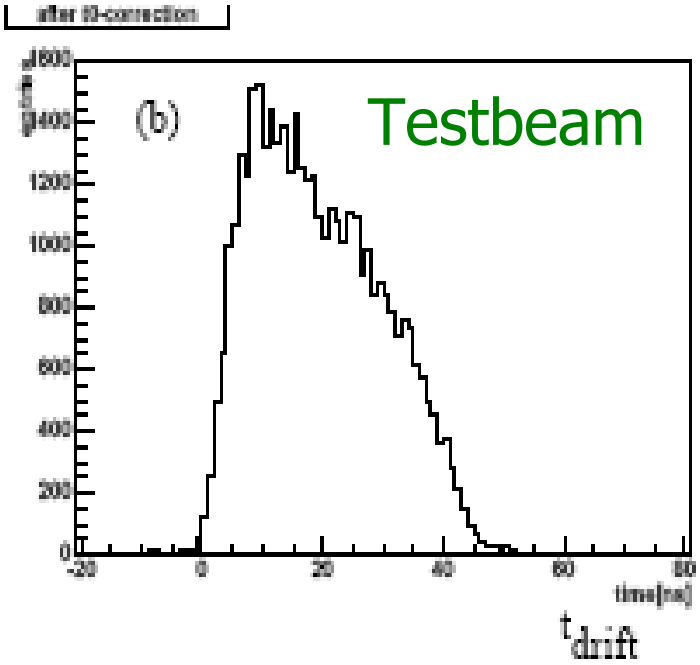
Additional benefits: Efficiency

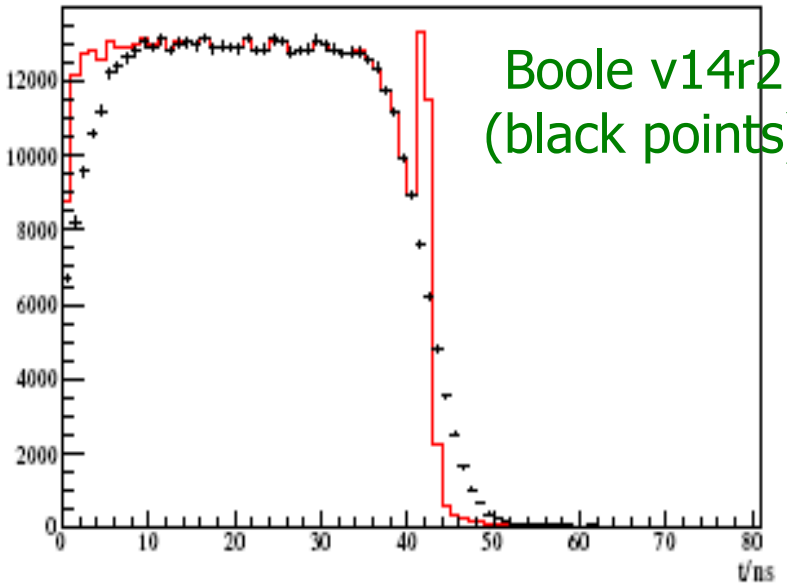


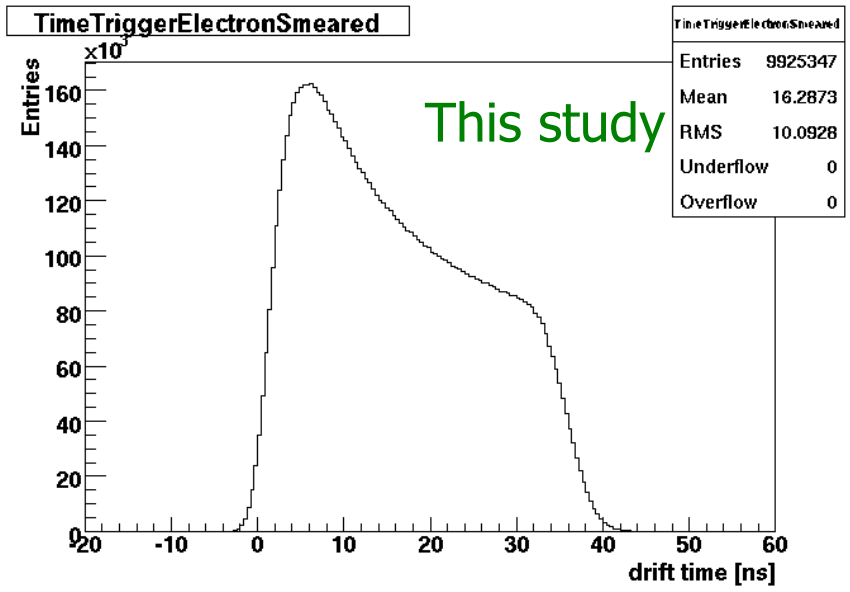
Eff.: 99.2%



Addition benefits: Drift time spectrum







What next?

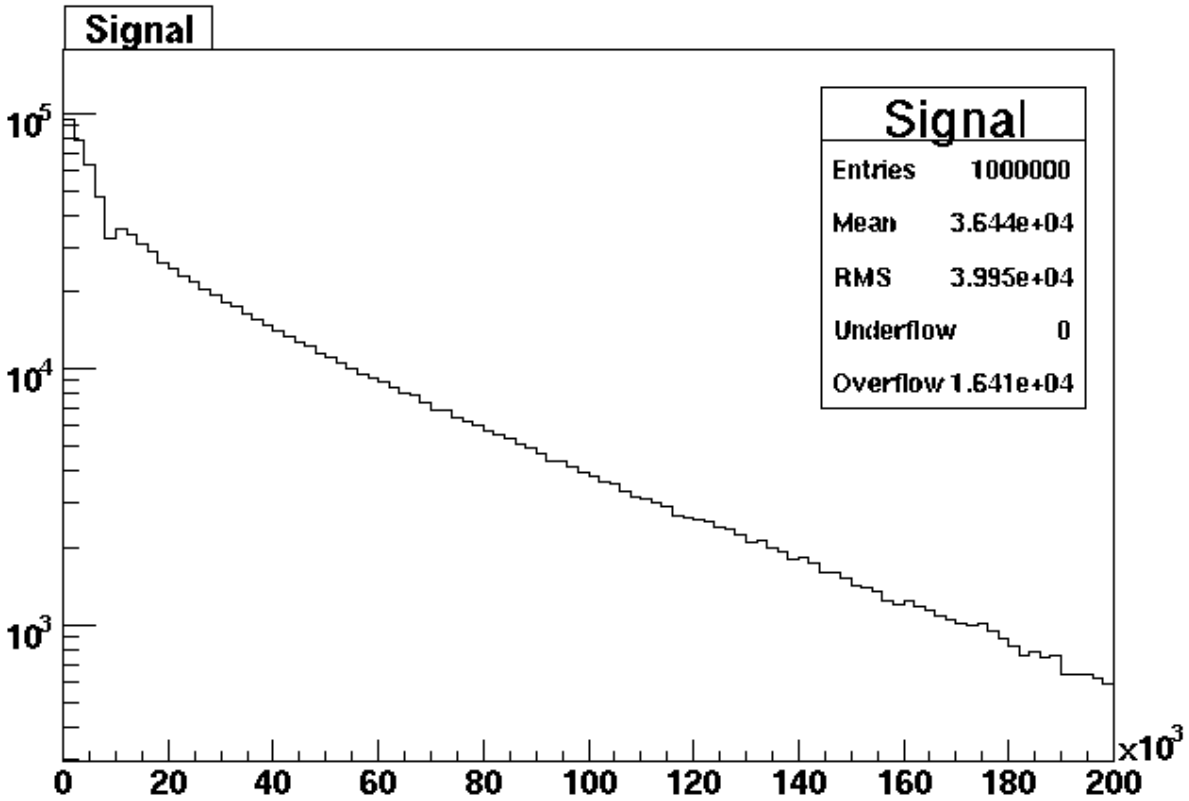
- Improve model (needed?):

  Add statistical fluctuation of gas gain.

  May help to simulate crosstalk and after pulses.
- Study impact on track fitting in a stand-alone mode.
- Implement new model into Boole. Study impact on reconstruction and track fitting.
- Study calibration procedure for rt-relation in MC.

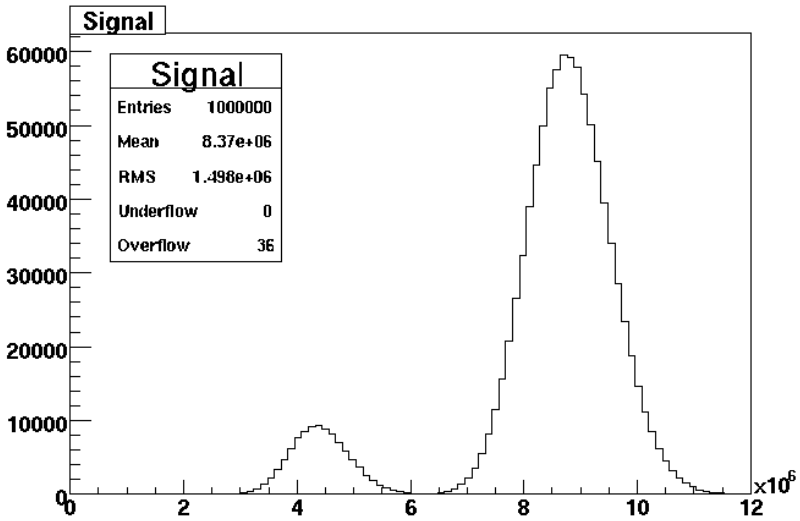
Gas amplification process

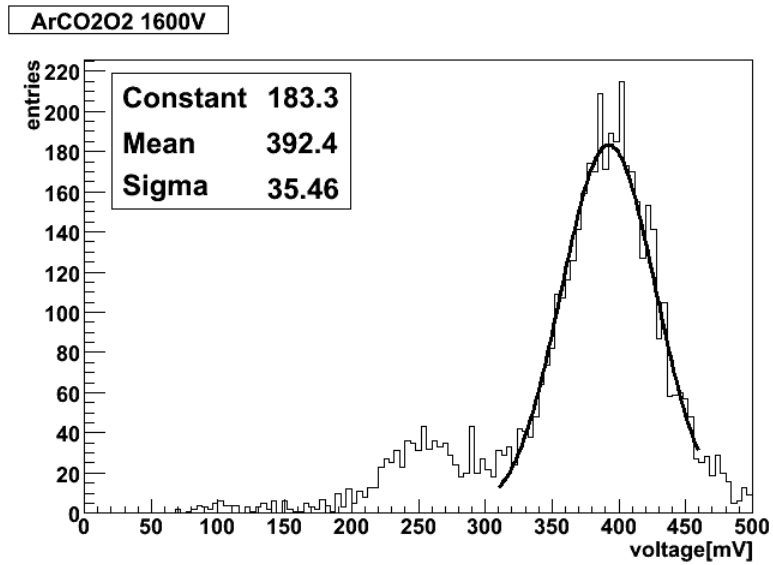
- Gas amplification process for a single electron follows a Polya-distribution:



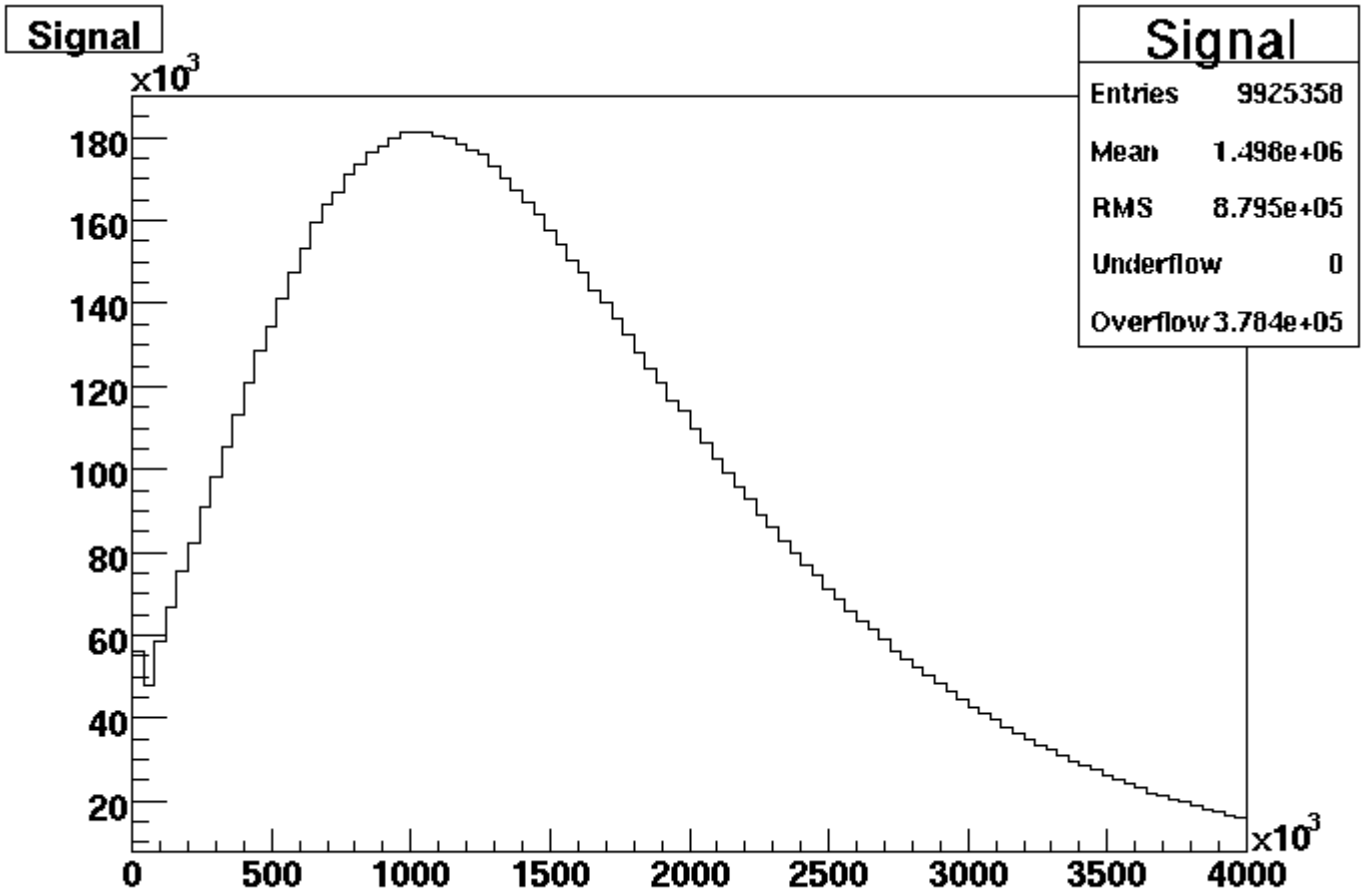
Response for a 6keV photon:

- 6keV photon produces about 220 electrons (main line):





Response to a MIP



Why simulating the signal?

We measure time, not pulse height. So why should we care about it?

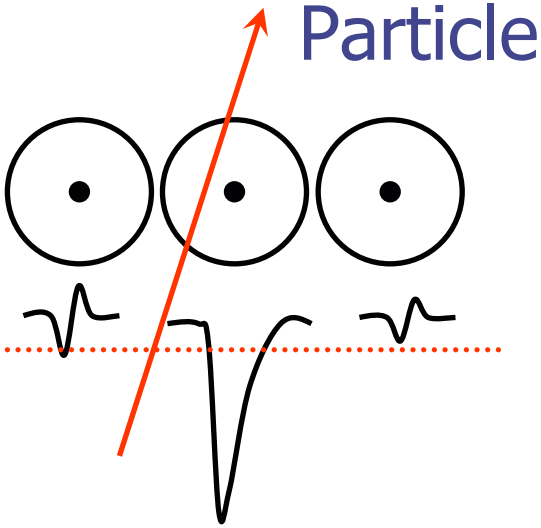
- Detector performance is affected by crosstalk and afterpulses. In the current implementation for the digitisation these two effects are treated independent.

  But in real life they are correlated as both effects occur only for large signals.

- This model allows a better description of this correlation.

- Also the timing for crosstalk and after pulses can be described correctly (to be done!).

Crosstalk



Signal from particle produces unipolar signal.

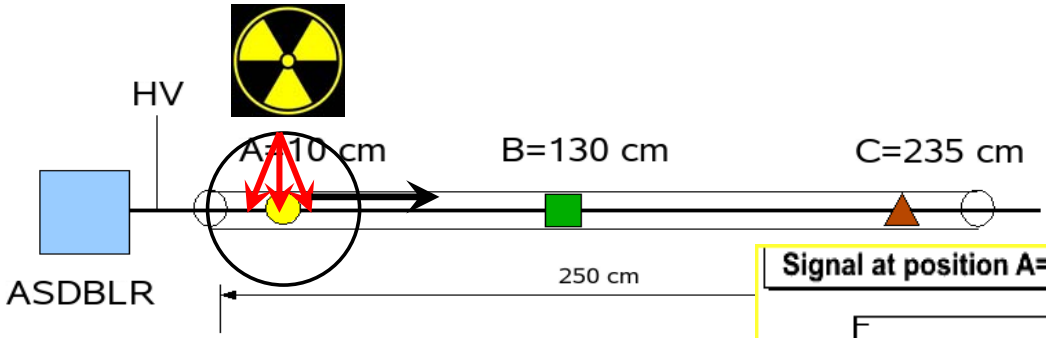
Capacitive coupling between two straws causes bipolar signal on adjacent straws. Ratio of amplitude between unipolar and bipolar signal is fix.

If signal exceeds threshold → Crosstalk hit.

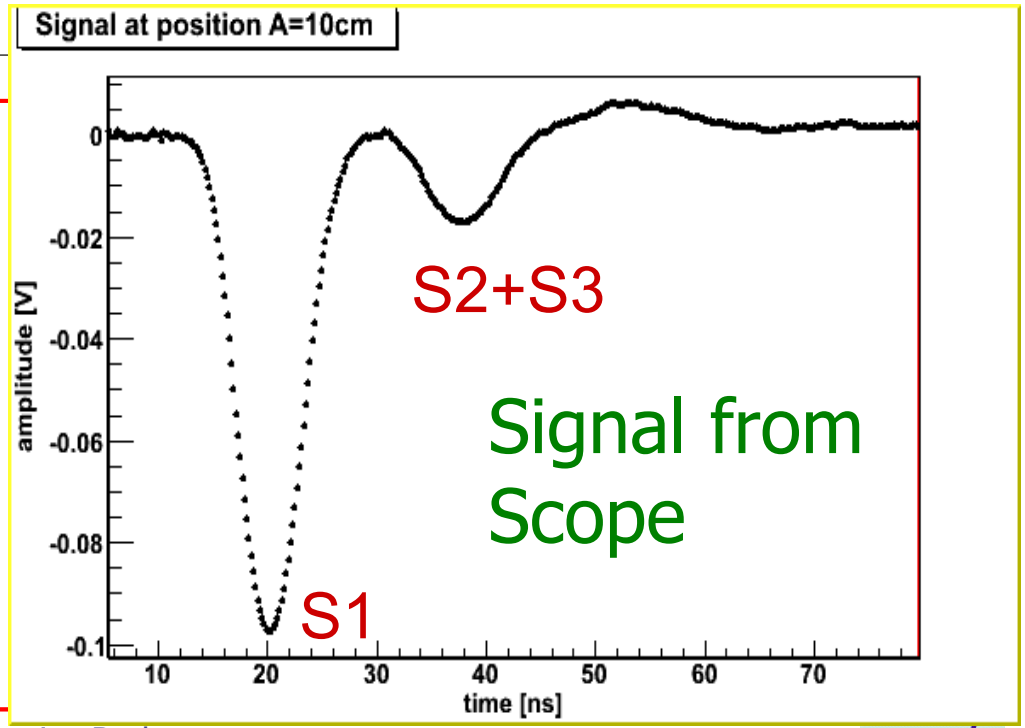
After pulses

^{55}Fe source
(similar to injection of δ–pulse)

M.Deissenroth



S2 + S3



What next?

- Implement new model for optional use into Boole.
- Study impact on reconstruction and track fitting.
- Study calibration procedure for rt-relation in MC.
- Implement a realistic timing for crosstalk and after pulses.